

A one metre diameter magnetic loop for 14 MHz

Jim Tregellas VK5JST

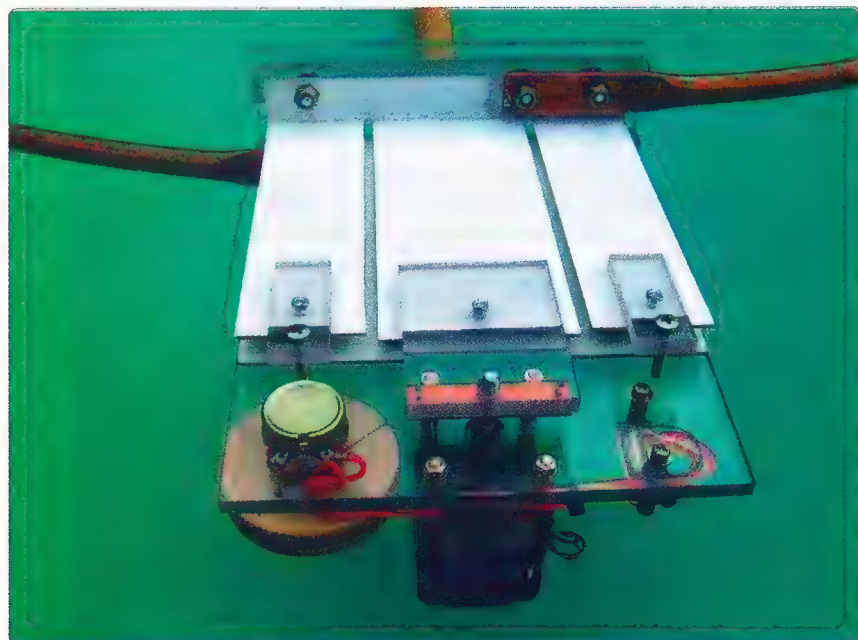


Photo 1a: The capacitor and stepper motor assembly.

Here is another design for a magnetic loop, and this time it is a 0.16 wavelength unit for the 20 metre band. Carefully built, it offers an efficiency of around 50% and will equal or better the performance of a half wave dipole. It will do this at a height above ground of three metres or more and in common with all loops has a very low radiation angle making it great for DX. This loop can be remotely tuned, and continuously operated at 100 watt power levels. It is intended to be installed out of the weather and out of sight under a non metallic roof and makes the perfect stealth antenna.

The theory

Reference should be made to my previous article (Reference 1), in which the theory behind the design of a magnetic loop and the selection of materials is covered in near exhaustive detail. This loop uses an identical approach, and also uses

the same controller circuitry and so there is no point in repeating this information.

The only significant differences between the two designs lie in the way the ultra low loss tuning capacitor is built and in the fact that 12.7 mm (half inch) copper water pipe is used for the main loop conductor.

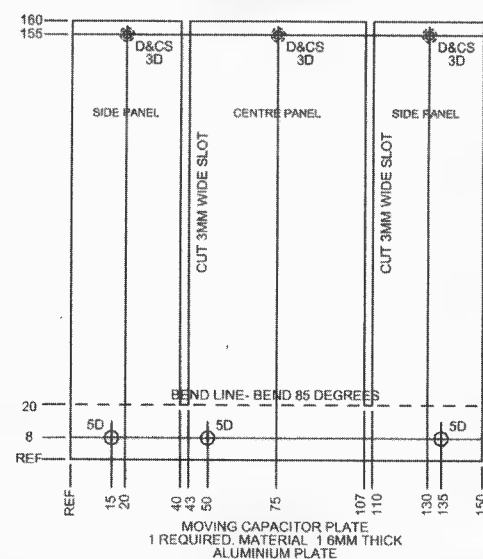
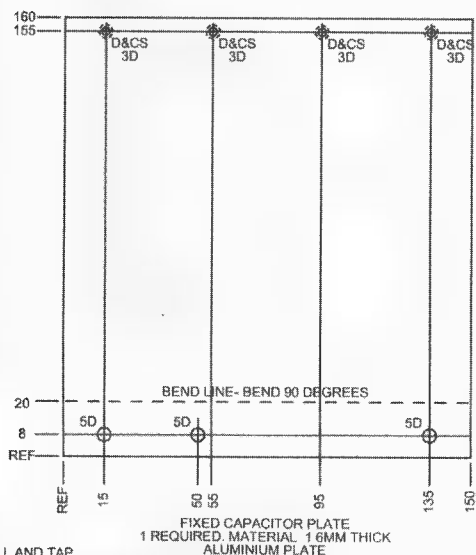
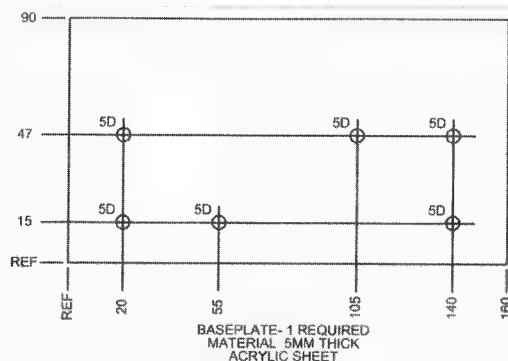
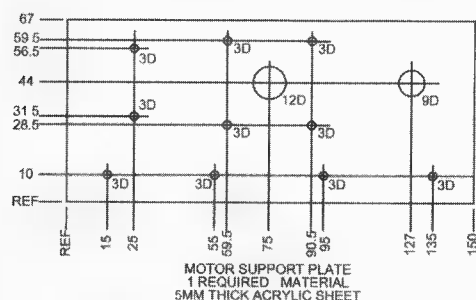
Dealing with this last point first, at 14 MHz and above it is absolutely vital that the main loop conductor has a very smooth surface. The depth of the 'skin' in which the RF current flows on the outside of a conductor decreases rapidly as the frequency rises, and so it is simply not possible to use rough materials like the outer sheath of ordinary coaxial cable (e.g. RG8 and RG213) without incurring losses which are totally unacceptable. Because skin effect forces the current to remain on the very outside surface of a conductor, these large losses result



Photo 1b: The capacitor and stepper motor assembly.

from the RF current having to hop from one strand to another in the sheath, as each strand disappears under another in the weaving. The result is a huge drop in the operating Q of the loop and a similarly huge drop in radiation efficiency. Of course, the outer sheaths of expensive and flexible coaxial cables such as LDF4-50 and LDF5-50 are still good propositions, but from a cost point of view are not as attractive as ordinary copper water pipe, which was used in this design. Despite the recent large increases in the price of copper, the 3200 mm length of water pipe used still results in a cheap antenna.

The design of the variable capacitor is novel, and relies on the fact that the operating frequency of the antenna only needs to be tuned from 14.0 - 14.35 MHz. This is a 2.5% frequency change, or just a 5% capacitance change, and so a simple, very low loss and high



D&T = DRILL AND TAP
D&CS = DRILL AND COUNTERSINK

DRAWN VK5JST JUNE 2010

Figure 1: The technical drawing for the various aluminium and acrylic plates used in the magnetic loop antenna.

current tuning capacitor can be designed by arranging to move its two plates slightly apart to vary the capacitance.

In fact, in this design, one of the two capacitor plates is split into three sections, and it is only the central section of this plate which is moved in and out under the control of a stepper motor to vary the operating frequency. The outer two sections of this plate are adjusted during the setting up process for the antenna but thereafter remain fixed in value.

The inter-plate spacing has been chosen as 5 millimetres minimum, meaning that the capacitor structure will happily cope with peak voltages of 15 kV, or RMS voltages of 10.5 kV. This is considerably in excess of the requirements for operation of the antenna at 100 watt power levels, but it is nice to have some margin up your sleeve for the inevitable day when some six or eight legged

Australian beastie crawls into the capacitor air gap.

Building the antenna

To make construction easy, one needs access to a good circular saw, a bench drill, and a flycutter. And of course the usual marking out tools, including a good square, a sharp scribe, and a centre punch. All of the parts detailed in the drawings should be carefully made up. A little cunning is in order, and the capacitor plates should be made first. These can then be used to check your marking out on items such as the acrylic bottom spacers and base plate, and the plate on which the stepper motor and 1 k Ω linear feedback potentiometer are mounted. Note that the flange on the fixed capacitor plate should be bent at 90 degrees, while the flange on the moving plate should be bent at 85 degrees. This ensures that due to

the tension of bending, the stepper motor will always determine the position of the central section of this plate. Note that provision has been made on the motor plate to mount a DB9 connector on 12 mm long spacers. All motor and potentiometer connections should be terminated on this connector.

When assembling the capacitor plates and spacers to the base plate, space the bottom of the two capacitor plates exactly 5 mm apart using a temporary spacer.

Do not omit the spacers between the flanges of the capacitor plates and the base plate. During initial testing, a rapid drift in SWR was observed during long overs. This was traced to heat build up in the acrylic base plate, caused by its immersion in the intense electric field existing between the lower edges of the two capacitor plates. This heating caused a change in capacitance which

detuned the antenna and raised the SWR. Adding the two spacers totally fixed this problem. Note that the operating Q of this antenna is around 850, giving a 3 dB bandwidth of about 16 kHz. This figure is really only relevant to receiving mode, because under transmit conditions, the antenna tuning only needs to vary about 3 kHz to seriously upset the SWR and so the temperature coefficients in the loop need careful control.

To form the main loop, the 3200 mm length of 12.7 mm (half inch) copper water pipe should be bent into a circle using a temporary jig. I used an old bicycle rim to which I firmly taped one end of the copper pipe. I then rolled the rim along the ground to form a slightly small but perfect circle of tube. This was opened out by hand to the 1 metre diameter required, and I then

flattened both ends of the tube in a bench vice over a distance of 65 mm. These flattened areas were then drilled with holes 35 mm apart to match the holes in the flanges of the capacitor plates.

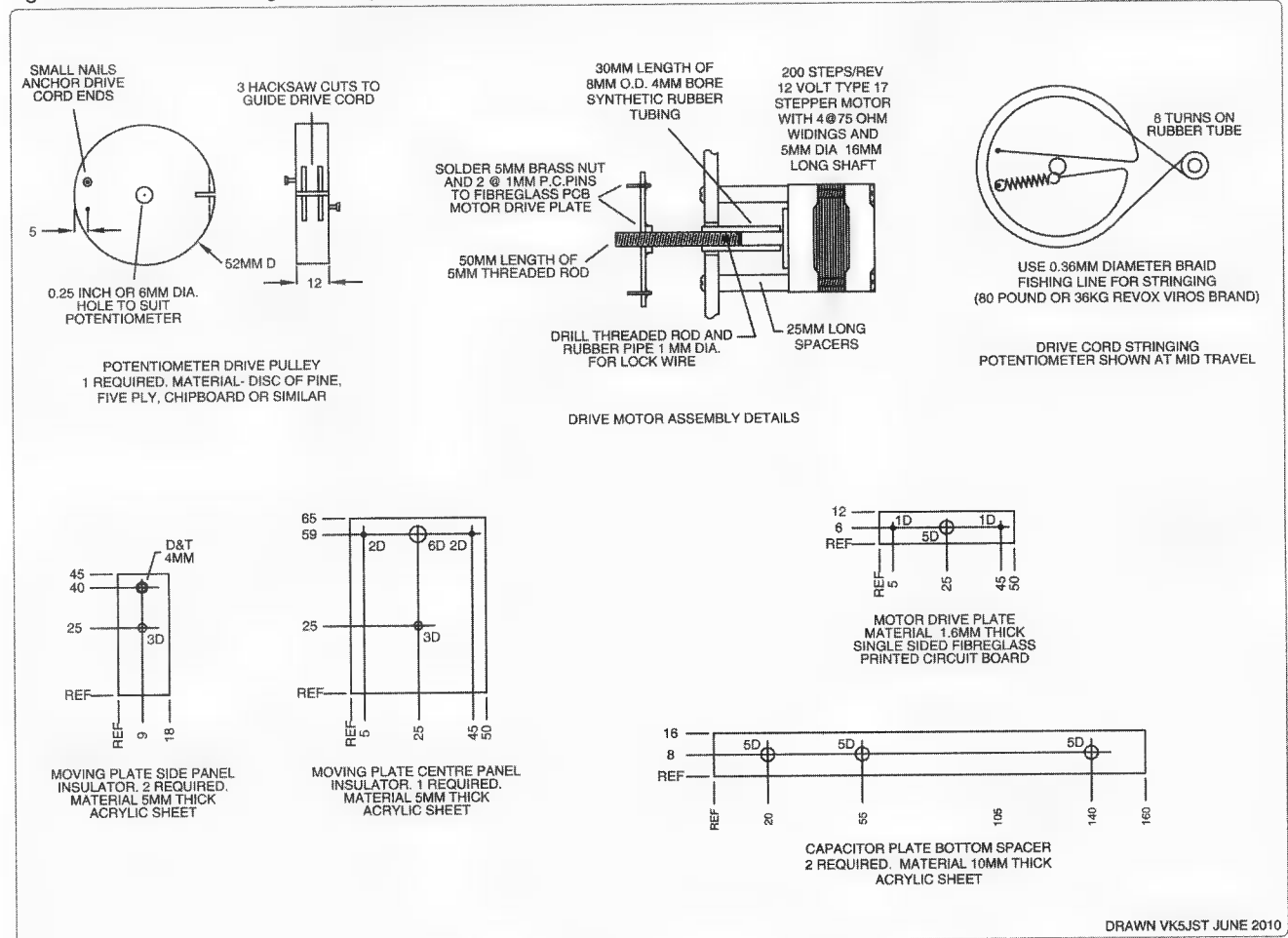
Note how drive from the stepper motor drive screw is transferred to the centre section of the moving capacitor plate. The piece of synthetic rubber tubing acts as a simple universal joint and the piece of printed circuit board with its two drive pins accommodates the bending of the capacitor plate as it moves back and forth.

Stringing the drive from the stepper motor may try your patience but it is worth persisting. Note the eight turns around the motor shaft. This, together with a piece of wire which passes through the rubber tube and drive screw ensures that there will be absolutely no slippage in

the potentiometer drive mechanism. Start your stringing on the nail on the potentiometer pulley closest to the motor support plate, which will allow you to finish your stringing (with tensioning spring) on a nail you can easily get to on the other side of the potentiometer pulley. Follow the diagrams closely. When you have finished, set your potentiometer to mid travel with the drive pulley in the position shown in the diagram and then lock the wooden pulley onto the potentiometer shaft with a dab of Araldite or similar. Alternatively, a small self tapping screw can be screwed into the gap between the flat on the potentiometer shaft and the pulley.

Make up the circular coupling loop from a 640 mm length of copper wire of around 2.5 mm diameter (or copper gas or hydraulic tube). As shown in the photos, position this

Figure 2: Technical drawings showing the drive motor assembly details, and capacitor and motor drive plate construction details.



at the bottom of the main loop at the current maximum opposite the tuning capacitor.

Finally, fabricate the control electronics as detailed in the previous article for the 80 metre loop in *Amateur Radio* magazine (Reference 1) and make up all interconnecting cabling.

Setting up

At the top of the capacitor, adjust the gap between the fixed plate and the central section of the moving plate to exactly 5 mm. This can be easily done by pulling the central section of the moving plate backwards, allowing the stepper motor drive plate to be spun up and down the drive screw. The potentiometer should be at one end of its travel when you do this. Using the adjusting screws provided on the top of the two outer sections of the

moving plates, adjust the antenna to resonance at 13.95 MHz. Try to equalise the two air gaps when doing this and keep your body well away from the loop to eliminate the effects of stray capacitance. The very high Q resonance will be difficult to find and you will need to tune your antenna analyser very carefully indeed. Alternatively you can look for the noise peak on a general coverage receiver.

Next, use the potentiometer and its motor drive to move the central section of the moving plate outwards and check that the antenna resonates beyond 14.35 MHz. The stepper motor will move through approximately five turns. If the SWR is not quite optimum, it can be adjusted by stretching or flattening the coupling loop, and/or by slightly overlapping the main and driver loop conductors.

To ensure that the cabling to the stepper motor and feedback potentiometer has no effect on the loop resonant frequency, run it horizontally away from the motor for about 600 mm and then drop it vertically. I used some shielded six core computer cable I happened to have which is readily available (Altronics W2710, Jaycar WB-1875). Because the motor windings are 75 ohms and only draw around 120 milliamps each, very long runs (50 metres) of control cable will have no effect on operation of the system.

Good DXing.

References

1. Building an 80 metre magnetic loop for your attic, Jim Tregellas VK5JST, *Amateur Radio*, July & August, 2011.

Silent Key

Don Graham VK6HK

VK6HK Don built and operated amateur radio station VK6HK after gaining his licence in 1951. Apart from his HF activities he was renowned for operation on 50 MHz as well as VHF, UHF and microwaves to 10 GHz. The development of the adjacent property with 2 two storey houses cramped his 6 and 2 metre activities in his final years. However he was one of the few Perth amateurs to work into South Australia and Victoria on 144 and 432 MHz. Don died on 13 January 2012.

Don was a Foundation Member, President for a number of years, Life member and Trustee of the WA VHF Group. He was the engineering genius behind the Group's state-wide beacon network. The first beacon was established to help research on the propagation of radio waves in the International Geophysical Year 1957. At the time of his death he was working with Andrew Martin VK3OE and Phil Harman VK6APH and others in the development of a software controlled digital identification

system, a chirp radar that has world-wide significance.

He was also a founder of the Perth Amateur Television Group, constructing the ATV repeater located on the Darling Scarp (since de-commissioned).

Apart from these, Don was a member of the WIA, a contributor to *Amateur Radio* magazine, a member of the WA Repeater Group and resurrected radio equipment for the Air Force Museum at Bull Creek.

Following National Service in the RAAF as a Wireless Maintenance Mechanic, his first job was at the Department of Civil Aviation (DCA). In 1960 he decided to further his education by starting a communications engineering degree at the Western Australian Institute of Technology (now Curtin University). By then juggling full time work at the PMG Department, and a young family, alongside his studies, it must have taken a lot of determination - and he successfully graduated in 1967.

He joined the Australian Broadcasting Control Board in 1970 as the Assistant

State Broadcasting Engineer, working on technical regulation and site planning later becoming the WA State Broadcasting Engineer for the Department of Transport and Communications for many years prior to retirement. He was regarded by the broadcasting industry as a fine engineer with an excellent understanding of broadcasting equipment, communications systems and radiofrequency propagation.

Don has left a lasting legacy and he has one final message for us amateurs. He showed his appreciation for the love and support of his wife Patricia by culling his "junk", indicating the likely sale value of his equipment and leaving advice on how to dismantle his tower. We should do similarly for our loved ones.

Wally Howse VK6KZ